

## REMARKS

This Response is submitted in response to the Office Action dated October 17, 2008, and in response to an Advisory Action issued on January 13, 2009. Claims 11-20 are pending. Claim 11-20 stand rejected under 35 U.S.C. §103(a), and further provisionally rejected based on nonstatutory double patenting. In response, claim 11 has been amended and new claims 21-23 have been added. A Request for Continued Examination is filed concurrently with this Response.

In the previous Office Action and in the Advisory Action, the Examiner states that claims 11-20 are provisionally rejected on the ground of nonstatutory double patenting over claims 14-26 of copending Application 10/536,934. Applicants take note of the rejection. Applicants also note that neither this application or nor the application asserted by the Patent Office have been granted as a patent with issued claims. At such a time as either this application or the other applications issues as a patent, then the remaining application may be examined in view of the issued claims and any possible amendments made to the claims remaining in prosecution to determine if indeed an obviousness rejection is appropriate and if a terminal disclosure is required. Until that time, the rejection remains provisional.

In the Office Action, claims 11-20 are rejected under §103(a) as being unpatentable over U.S. Patent No. 5,250,167 to Adolf et al. (“Adolf”), in view of Hirai et al. ((2003) Proc. of SPIE 5051: 198-206), U.S. Patent No. 6,249,076 to Madden et al. (“Madden”), and U.S. Patent No. 6,475,637 to Shahinpoor et al. (“Shahinpoor”).

In response, Applicants have amended claim 11 and added new claims 21-24. Claim 11 recites, at least in part, a polymer actuator including: a plurality of gel/electrode complexes arranged in an electrolytic aqueous solution, at least one of each gel/electrode complexes being composed of a polymer gel *containing acidic functional groups and electrodes in the polymer gel* and at least one of each gel electrode complexes being composed of polymer gel *containing basic functional groups and electrodes in the polymer gel*. The electrodes is made of a material capable of *occluding and releasing hydrogen electrochemically*, such that the polymer gel in each gel/electrode complex *changes in pH due to occlusion and release of hydrogen from the electrodes* upon application of voltage across the electrodes of the gel/electrode complexes. Each of the gel/electrode complexes changes in volume in response to the pH change from the

occlusion and release of hydrogen. Support for the amendment can be found throughout the specification, and specifically at pages 8-11. Additional claims 21-23 have been added. Support for these additional claims can also be found throughout the specification, and specifically at pages 8-9 for claims 21 and 22, and page 10 for claim 23.

Applicants amended claim 11 to help distinguish two key limitations that are not supported by the prior art. First, the change in pH of the gel/electrode complexes which leads to mechanical action by the gel/electrode occurs due to the release or occlusion of hydrogen from the electrodes (and more specifically palladium electrodes as noted in claims 12 and 13.) None of the art cited by the Examiner provides support for the limitation that the pH change occurs due to occlusion and release of hydrogen from the electrodes. Instead, the prior art references cited by the Patent Office either rely on electrolysis of water to effect a change in any gel complex, or do not effect a change in pH at all. (Electrolysis of water leads to consumption of the water and evolution of gas – problems which the current invention specifically overcomes.) Specifically, Adolf does not teach occlusion and release of hydrogen that changes the pH. Adolf relies on establishing a pH gradient at the two separate electrodes, and specifically refers to the devices as electrolysis cells. Hirai does not rely on pH change at all, but instead on electric field induced deformations. Madden does not rely on pH change either, but instead relies of electrical deformation. Shahinpoor merely measures or effects mechanical deformation using electrical field induced deformations. None of these references describes a pH changed effected by occlusion and release of hydrogen from an electrode. Because none of the references supplies this limitation to the claim, the combination of references does not render the claimed invention obvious.

Second, the electrodes must be incorporated into both gels in order to support the pH changes, forming at least one acidic gel/electrode complex and at least one basic gel electrode complex in an electrolytic aqueous solution. Both types of gel electrode complexes are required. None of the references supports this limitation. At best, Adolf teaches a basic gel and an acidic gel in an electrolytic aqueous solution. However, Adolf does not embed the electrode within the gel. Hirai does not embed the electrode within the gel but merely sets the gel on top on an electrode to measure deflection due to dielectric effects. Madden does not embed the electrode within the gel, but uses a conductive polymer attached to an electrode. Shahinpoor does not

embed the electrode in the gel, but instead coats metal on the outside surface of an ion exchange membrane, and does not create a coating inside an ionic polymer gel. Because none of the references supplies this limitation to the claim, the combination of references does not render the claimed invention obvious.

Applicants also reiterate that the Examiner is selectively picking and choosing elements from four different references to achieve the claimed invention, despite the fact that the references do not supply the specific limitation and often teach away from the experimental results achieved by the currently claimed invention. Hirai specifically demonstrates that conclusion. Hirai notes in its Introduction that polymer gels and materials swollen with solvent and controlling the gel volume through composition, pH, ionic strength, etc. – conditions which would be applicable to the current invention. However, in the next paragraph, Hirai notes that swollen gels are inconvenient in practical use because they are hampered by diffusion limitations, and deformation without diffusion is desirable. Furthermore, Hirai notes that “deformation processes are electrochemical reactions on the electrodes, which are irreversible chemical processes or chemical consumption that limit the life span of the materials.” (emphasis added.) Hirai then goes on to point out that non-ionic polymer gels with no explicit chemical reaction or chemical consumption are preferred. These non-ionic polymer gels achieve mechanical action by dielectric-type deformations. The balance of Hirai describes nonionic gels such as polyvinyl alcohol, polyvinyl chloride and polyurethanes and the activities in electrical field deformation.

The claimed invention demonstrates exactly the opposite conclusion asserted by Hirai by using ionic polymer gels, i.e. acidic and basic gels, via electrochemical reactions on electrodes that are reversible (i.e. occlusion and release of hydrogen) with no chemical consumption of material (because the hydrogen previously released by an electrode can be occluded in the reverse reaction.) This results in linear contraction and expansion without curved displacement – the problem that conventional gels are plagued by. Hirai asserts that ionic polymer gels are unacceptable for the several reasons and that non-ionic polymer gels are preferred. Applicants have shown exactly the opposite – that ionic polymer gels as described by the claimed invention will work.

Madden also does not teach the limitations that the Examiner asserts. The Examiner asserts claim 1, which teaches an electrolyte, a counter electrode, and active member, the active member comprising a polymer which is capable of exerting a force per unit area with application of an electrical potential between the active member and the counter electrode. Again, the limitations asserted by the Examiner are taken out of context of the reference. The polymer in Madden is not an acidic or basic gel electrode required by the claimed invention. The polymer in Madden is a conductive polymer such as polyaniline or polypyrrole. This conducting polymer is attached to an electrode, which can indeed be palladium, and the conducting polymer then conducts a charge down its length. A counter electrode in contact with the electrolyte then provides an opposite charge and the conducting polymer can mechanically deflect relative to the counter electrode. While presumably an elegant design, this is not a gel electrode complex as defined by the claimed invention. The electrode is not embedded in the polymer gel matrix. And clearly the mechanism of action is not hydrogen occlusion and release.

To further emphasize that discrepancy, Applicants have pointed previously to the section of Madden that teaches the conducting polymers are not electroresponsive polymers. "Note that conducting polymers are different from other electro-responsive polymers described in the literature. Polymers described, for example, in U.S. Pat. No. 5,389,222, entitled "Spring-Loaded Polymeric Gel Activators" to Shahinpoor, and in U.S. Pat. No. 5,100,933, entitled "Collapsible Gel Compositions" to Tanaka, are gels and are not electronically conductive. Any conduction exhibited by these gels occurs strictly by the transfer of ions. In contrast, in conducting polymers, charge is transported along the polymer backbone and between chains...." Madden, Col 3. lns. 16-24 (emphasis added.)

Finally, Shahinpoor does not teach the limitations the Examiner asserts. The Examiner relies on Shahinpoor for the alleged disclosure of "a porous conductive layer embedded in said polymer with penetration inside said polymer comprising at least two embedded electrodes wherein application of an electric potential across said electrodes causes movement of said polymer in a dry environment." See, Office Action, pg. 4. Applicants note that the primary Adolf reference is discussed in detail in the background section of Shahinpoor. (See, col. 2, lines 21-39). In particular, Shahinpoor appears to tout the disadvantages of using polymeric gels: "the disadvantage is that actuator performance is dictated by the parameters of the polymeric gel used

... furthermore, liquid containment is required to make the actuators stronger and not so easily broken." (See, Shahinpoor, col. 2, lines 35-39). In addition, Shahinpoor discloses that "the sensors of the present invention also have a very broad bandwidth and can sense oscillatory motion at rates of up to hundreds of Hz, unlike most polymeric gels." (See, Shahinpoor, col. 14, lines 4-7).

Furthermore, Shahinpoor provides only for the electrode coated on the outside of a structure, not embedded within the polymer gel. Throughout Shahinpoor, the specification describes coating a metal on the surface. Note that coating is specifically defined by Shahinpoor as "depositing a layer (porous and nonporous) when used as a verb, and as a deposit (porous and non-porous) when used as a noun." Shahinpoor, col. 13, ln. 52-55. These are not electrodes composed of a metal that is embedded within the polymer gel to make a gel electrode complex.

Accordingly, Applicants assert that, in addition to not supplying the specific limitations of the claimed invention, the elements and references extracted by the Examiner in the prior art references do not support the conclusion ascribed to them when view in the context of the document as a whole. In many cases, the element cited by the Examiner is utilized in the reference to reach conclusions that are opposite to the results that the Applicants have demonstrated in the claimed invention. In effect, the Examiner has misinterpreted scope and content the prior art to reach conclusions that are not justified by the context in which they are given.

Finally, the combination of the references, even if properly combinable, requires the use of improper hindsight. In order to craft an obviousness rejection, the Examiner has relied on no less than four references, selectively picking and choosing elements from each of those disclosures to build the Applicants' claimed actuator. Ignoring for the moment that many of the elements selected by the Examiner do not actually contain the characteristics the Examiner ascribes to them, such picking and choosing of elements from multiple sources is improper hindsight analysis. As asserted in the Office Action,

"it would have been obvious ... to combine the teachings of Adolf, Hirai, Madden, and Shahinpoor, along with many other prior art teachings as enumerated in each of these, to create a polymer actuator using a gel/electrode complex. Various configurations of gel, electrode, chemical reactions, and structures would be known in the art to provide the most motive force with the most stable system. As Hirai state[d], 'the concept proposed is simple and can be applied to a wide range of materials'.... One would have a reasonable

expectation of success in creating a gel/electrode actuator using the various systems as described in the prior art since many variations were already known and information on the construction, use, force available, reliability, and durability of various configurations was publicly available.

Final Office Action, page 4. However, despite the alleged obviousness of the claimed invention in view of all the prior art, the Examiner has not been able to cite a reference where someone else has made this invention, and has not cited a reference describing the occlusion and release of hydrogen from an electrode contained within a polymer gel. Instead the Examiner cites to four references broadly, as well as "to the many other prior art teachings" without pointing to specific support in the prior art for each and every claim limitation. The lack of these elements and the need to cite to four references, not to mention "many other prior art teachings" suggests that in fact the claimed invention was not obvious.

For at least the reasons above, Applicants respectfully request withdrawal of the 35 U.S.C. §103(a) rejections of Claims 11-20. Accordingly, Applicants respectfully submit that the present application is in condition for allowance and earnestly solicit reconsideration of same. The Commissioner is hereby authorized to charge deposit account 02-1818 for any fees which are due and owing.

Respectfully submitted,

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